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July 5, 1983

## AGU (cont. from p. 447)

AGU will acknowledge receipt of all abstracts. Notification of acceptance and scheduling information will be mailed to corresponding authors in early December.

## Abstracts

The abstract page is divided into two parts: the abstract itself and the submittal information. Please follow carefully the instructions for each part. Use a carbon ribbon to type the material, and do not exceed the maximum dimensions (11.8 cm by 18 cm) of the abstract. Abstracts that exceed the noted size limitation will be trimmed to conform without regard to content.

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Numbers refer to the items in the submittal information block on the sample abstract.

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## Poster Sessions

A large, centrally located meeting room will be set up for poster presentations. Experience from recent AGU meetings and from other scientific societies has shown that a poster presentation, while more demanding of the author, can provide a superb opportunity for comprehensive discussions of research results.

If individual papers are deemed by a program chairman to be suitable for this type of presentation, they may be so assigned.

Presenters of poster papers are reminded that a poster exhibit requires careful preparation. Figures and text will be scrutinized in detail, and authors must be prepared to discuss the contents of their papers in depth. Under these conditions, well-prepared figures and concise, logical text are essential.

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## Special Sessions

Warm Core Rings

Air-Sea Interaction in Coastal Regions

Shelf Dynamics: CODE

Optical Dynamics Experiment

Marginal Ice Zone Experiment

California Current

Gulf of Mexico/Caribbean: Biological, Chemical, and Physical Oceanography

Southern Oceans: Dynamics, Biomass

Kuroshio

Arctic Ocean: Dynamics, Biology, Acoustics

Seafloor Spreading Centers

El Niño and Climate Variability

El Chichón, Global Climate, Chemistry

Oceans and Atmospheric Chemistry: CO<sub>2</sub>

N<sub>2</sub>, Freons

Ocean Heat Transport: Climate, Paleoclimatology

Acoustic Monitoring: Suspended Particulate

Biology

Acoustic Remote Sensing: Fine Structure, Internal Waves, Mesoscale Features

Acoustic Imaging: Seafloor, Precision Bathymetry

Acoustic Tomography

Large-Scale Ocean Observing Systems

SAR Surface Signatures

Ocean Tracers

Radioactive Disposal

Environment and Fisheries Year Class Summary

Zooplankton Behavior

Plankton Growth Rates in Oligotrophic Waters

Below Ground Processes in Wetland Ecosystems

Phytoplankton Responses to Fluctuating Environments

Aquatic Nitrogen Cycle

Interrelation of Optical and Biological Processes

Dynamics of Microaggregates in Oceanic Systems

Organism Growth and Behavior in a Turbulent Fluid

Biology and Physics of the Benthic Environment

Feeding Ecology of Fishes

Cyanobacteria: What Are They Doing?

## IUGG Quadrennial Report Overview

## Solar-Planetary Relationships:

## Aeronomy 1979-1982

Richard S. Stolarski

NASA/Goddard Space Flight Center, Greenbelt, MD 20771

Aeronomy is the study of the physics and chemistry of the upper atmosphere. The upper atmosphere is usually defined as the region of the atmosphere above the tropopause extending upward to the point where electric and magnetic fields dominate the phenomena rather than the atmospheric atoms and molecules. The lower part of this region, from about 10 to 90 kilometers altitude, has become known as the middle atmosphere. An international program called MAP (Middle Atmosphere Program) is now underway to intensively study this region. Three reviews of work in the middle atmosphere appear in this volume covering the composition, dynamics, and electrodynamics. Susan Solomon's paper, "Minor Constituents in the Stratosphere and Mesosphere," documents the continued growth in knowledge concerning the composition of the middle atmosphere, the mechanisms which maintain this composition, and

its possible response to outside influences. Dennis Hartman's review, "Middle Atmosphere Dynamics," examines the large-scale dynamics and climatology of the middle atmosphere, particularly pointing out the importance of the introduction of transformed Eulerian mean equations for dynamics and transport and the realization of the importance of gravity waves for the momentum budget of the stratosphere. Michael Kelley's review, "Middle Atmosphere Electrodynamics," discusses a variety of new techniques that have been used to obtain "existing and controversial" results including large (several volt/meter) fair weather electric fields in the mesosphere.

Above the middle atmosphere is the region referred to as the thermosphere or ionosphere, depending on which properties of the region are being emphasized. The review of this region is again divided into several papers. Douglas Torr's "Neutral and Ion Composition of the Thermosphere" summarizes the continued advances in the understanding of how solar extreme ultraviolet radiation interacts with and determines the composition and structure of the thermosphere. He emphasizes the significant contributions of the Atmosphere Explorer Satellite series. Raymond Roble, in "Dynamics of the Earth's Thermosphere," puts his emphasis on questions concerning the global circulation, temperature, and compositional structure of this highly variable region. "Ionospheric Electrodynamics and Irregularities" are covered by Arthur Richmond with emphasis on the modeling and data concerning the global electric

circuit. This both the middle atmosphere and the thermosphere are described in three reviews emphasizing different aspects of the physics and chemistry of the respective regions. A further report, "U.S. Contributions to Auroral Aeronomy, 1979-1982" by M. H. Rees, is devoted mainly to the special aspects of the thermosphere which are initiated in the auroral region by particle precipitation. Finally, the "Aeronomy of the Inner Planets" by Toin Cravens and Andrew Nagy covers the recent advances in understanding of the thermospheres of Mars and Venus, providing a summary of the recent Pioneer Venus results.

## Contents: IUGG Quadrennial Report Solar-Planetary Relationships: Aeronomy

U.S. Report to the IUGG, 1979-1982: Solar-Planetary Relationships: Aeronomy, R. S. Stolarski

Dynamics of the Earth's Thermosphere, R. G. Roble

Ionospheric Electrodynamics and Irregularities: A Review of Contributions by U.S. Scientists from 1979 to 1982, A. D. Richmond

U.S. Contributions to Auroral Aeronomy, 1979-1982, M. H. Rees

Neutral and Ion Composition of the Thermosphere, D. G. Torr

Aeronomy of the Inner Planets, T. E. Cravens and A. F. Nagy

Middle Atmospheric Electrodynamics, M. C. Kelley

## U.S. National Report to IUGG 1979-1982

*EOS* is periodically publishing the 12 overviews appearing in the U.S. National Report to the International Union of Geodesy and Geophysics 1979-1982. The U.S. National Report is being published by AGU on behalf of the U.S. National Committee in four extra issues of *Reviews of Geophysics and Space Physics* (RGSP). The discipline overview appearing here was published with its associated papers (see Contents list at the end of the overview) in volume 21, number 3, March 1983 of RGSP.

Subscribers to RGSP will automatically receive the four extra RGSP issues containing the U.S. National Report. All four extra issues will have been mailed by July 1983. The four regular issues of RGSP are appearing as usual in February, May, August, and November. Those who do not subscribe to RGSP can still obtain the entire U.S. National Report by entering a subscription to RGSP. In addition, the report of each discipline will automatically be mailed separately to those members of AGU for whom that discipline is their primary AGU section affiliation; this separate distribution is made possible by grants from the Defense Mapping Agency, National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, National Science Foundation, Office of Naval Research, and U.S. Geological Survey.

Minor Constituents in the Stratosphere and Mesosphere, S. Solomon

Middle Atmosphere Dynamics, D. L. Hartmann

## News

## Arctic Air Chemistry: Haze Analysis

The microparticulate (i.e., aerosol) and gas concentrations in Arctic air masses are being assessed currently as a result of a large-scale, multinational cooperative study made this spring. It turns out that many of the ideas about the origin of Arctic haze, industrial pollution, soil particles from the great desert regions of eastern China and Mongolia, and seasonal effects, to name a few, may all be valid. A recent report about the first extended airborne measurements of Arctic haze that were made during March and April of this year stated: "Most of the scientists on board the NOAA plane found the haze to be much denser and more extensive than they anticipated" (*Environ. Sci. Technol.*, June 1983).

The results of these studies will be presented at the third Symposium on Arctic Air Chemistry, to be held in May 1984 at Toronto. Within the myriad character of Arctic air patterns (chemistry, seasons, and climate) can be found the pleasant fact that at times of the year—late spring and summer—the Arctic is free of pollution and haze; the air is pristine and clear. During that period, aerosols and pollutants are scavenged and the atmosphere is clean because of its remoteness from major polluting sources. By late October, however, the Arctic air dries, and air masses containing the emissions from industrial sources far away are transported slowly over the northern polar region.—PAIB

and it generated large numbers and types of air chemistry measurements.

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## Lost Island Found

An abandoned 11-by-5-km kidney-shaped chunk of freshwater ice, used as a research station for 25 years, was rediscovered after the National Oceanic and Atmospheric Administration (NOAA) lost track of the island for 8 months. The recent find may foreshadow another loss, however: The island is drifting through the Greenland Sea and into the North Atlantic where it should melt within several months and dump its cargo of oil drums, equipment, and a wrecked plane into the ocean.

Known as Fletcher's Ice Island—after Joseph O. Fletcher, a member of the first team of researchers to inhabit the island and a recently retired NOAA climate researcher—the ice chunk has already melted to a third of its original 49 m thickness. A pilot flying over the area to measure annual pollution buildup in the Arctic located the drifting island 242 km from the North Pole near the International Date Line.

Identified by Fletcher as a fragment of the Ellesmere Island ice shelf, the island was the home for a number of Air Force, Navy, and NOAA scientific teams that provided weather reports and conducted experiments. Before satellites superseded the research and forecasting functions of the teams on Fletcher Island, the station also was a valuable site for observing oceanic and atmospheric circulation. First occupied in 1952, the island was abandoned in the mid 1970s.

In addition to its historical significance to scientific research, the site gained notoriety when a man on the island lost his life in an argument over a bottle of wine.

## New Climate Center

An Experimental Climate Forecast Center has been established at the NASA Goddard Laboratory for Atmospheric Sciences (GLAS) by the National Oceanic and Atmospheric Administration's (NOAA) National Climate Program Office. NASA's Goddard Laboratory will provide the computing facilities necessary to process the vast amount of data used in complex numerical climate modeling.

As the second of the centers established under the National Climate Program Act of 1978, the Experimental Climate Forecast Center will investigate climate predictability theory and forecasting techniques by using numerical methods in dynamic models of the earth's ocean and atmosphere system. The first center, at the Scripps Institution of Oceanography, concentrates on statistically based methods. The principal interest of both centers is the potential for forecasting characteristics of seasonal temperature and precipitation. The director of the new center is Milton Halen; he also will continue as head of the global modeling and simulation branch at GLAS.

NOAA's National Climate Program supports research on improving forecasts of next season's and perhaps next year's weather to aid planning for crop fertilization and irrigation schedules, geographical distribution of heating fuel, and maintenance of urban fresh water supplies.—BTR

## NASA FY1984

The White House budget request for the National Aeronautics and Space Administration (NASA) for fiscal year 1984 contains a number of continuing problems for outside investigators in universities and in the private sector. Nonetheless, the budget climate for NASA seems to be improving. (For more information on the budget for FY1984, see *EOS*, February 15, 1983, p. 65, and May 17, 1983, p. 378.)

Several new program starts are responsible for the feeling of optimism being sensed in many sectors of the scientific community. These include the Venus Radar Mapper, a shuttle-tethered satellite to study the earth's upper atmosphere (the tether could be 100 km in length), and the EUVE experiment (Extreme Ultraviolet Explorer).

The problems that remain in the budget are unfortunately rather focused on the geophysics academic community. For example, research and analysis funds are reduced in the FY1984 request to about what they were in the FY1983 request because Congress restored the funds cut last year. This year, the battle is going on again in both Houses, and at this point it appears as though the cut funds may be replaced again, particularly if Congress is supported by the scientific community as it was last year.

In FY1983, the research and analysis appropriation was \$60.3 million. This fiscal year it is down to \$45.6 million, but by mid-August the new appropriation may restore the cut. The budget request overall is set by the Office of Budget and Management at \$7.106 billion, which is an increase of 3.75%.

The space science portion of NASA's budget has been boosted significantly for FY1984 by about 14%. The Gamma Ray Observatory is back on a schedule with a launch date of 1988. The Venus Radar Mapper will fly also in 1988, to be launched by the shuttle-Centaur upperstage. The Galileo mission is to

be launched by Centaur in 1986 and will arrive at Jupiter in 1988.

NASA will not send its half of the two-satellite experiment in the 1986 launch of the International Solar Polar mission. Funds are being aimed at supporting the remaining single spacecraft of the European Space Agency.—PNB

## Hess Centennial

June 24 marked the 100th birthday of Victor F. Hess, the discoverer of cosmic radiation. The Austrian-born scientist received the Nobel Prize in physics in 1936 with Carl Anderson of the California Institute of Technology, who discovered the positron. When he died in 1964, Hess had more than 150 articles and publications to his credit.

In 1910, while a lecturer at the University of Vienna, Hess launched an unusual series of experiments to measure the conductivity of air. He made 10 balloon ascents, half of these at night. On the basis of these experiments, he concluded that "radiation of very high penetrating power enters our atmosphere from above." One ascent made during a solar eclipse proved that the sun could not be the main source of cosmic rays.

Hess made his first trip to the United States in 1921. Under his supervision, a research laboratory, the United States Radium Corporation, was built in New Jersey; he served for 2 years as the corporation's director and chief physicist.

Hess then returned to Austria to the University of Graz, where he later became dean of the faculty. He accepted a position at the University of Innsbruck in 1931 and established a laboratory for the observation of cosmic radiation there. Six years later he returned to Graz. In 1938, after Hitler's Germany annexed Austria, Hess fled with his wife, who was Jewish, to Switzerland. While in Geneva, Hess was offered a full professorship by Fordham University. He accepted and moved back to the United States. Hess retired from Fordham in 1958.



Victor F. Hess

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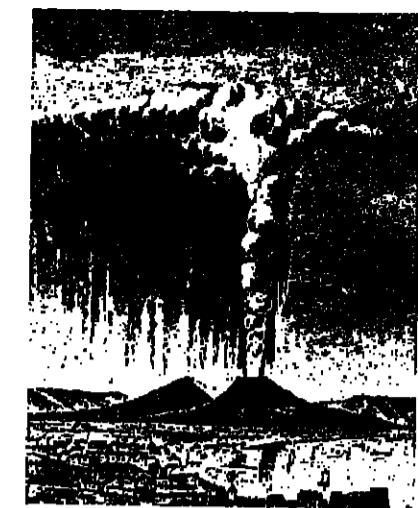
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# The VGP News



Editor: Bruce Doe, 11721 Dry River Court, Reston, VA 22091 (telephone 703-860-8170, after 5:30 p.m.).

## Sigurdur Thorarinnsson 1911-1983



Charles A. Wood

In March 1875 a number of farms were abandoned in eastern Iceland as a consequence of the great eruption of Askja volcano. The abandonment of one farm, however, had to be delayed as the family was expecting a child. In the spring a son was born. He was Thorarinn, the father of Sigurdur Thorarinnsson. This incident is merely one example of the dynamic interaction between man and nature which is so typical of Iceland. Here the geological mill, fueled by vigorous volcanism, glaciers, and swift rivers, grinds faster than elsewhere on earth. Here the existence of a small nation is continually responding and adjusting to the environmental pressures generated by rapid and sometimes catastrophic earth processes.

Sigurdur Thorarinnsson died in Reykjavik on February 9, 1983, at the age of 71, following a brief illness. Born on January 8, 1912, he was the leading Icelandic earth scientist of the 20th century and acquired international renown for his research in volcanology. The list of accomplishments of this remarkably versatile man is indeed impressive. He pioneered the development of tephrochronology as a branch of earth science, first as a key to the volcanic history of Iceland. The fruits of this research included a monograph on the eruptions of Hekla in historical times and led to the important discovery of a regular relationship between the length of repose period and the silica content of Hekla's magmas.

Sigurdur witnessed or studied all volcanic eruptions in Iceland since 1934. Probably no other scientist has accumulated comparable field experience on active volcanoes. His accounts of the birth and growth of the volcanic island of Surtsey are classics in volcanological research and clarified our understanding of the role of seawater in hyaloclastite formation, the characteristics of base surge activity, and the evolution of table mountains. He immediately embraced the concepts of plate tectonics and applied them to interpretation of the structure of Iceland as early as 1965. He also made important advances in glaciology and contributed to the understanding of the relationship between geothermal activity in subglacial volcanoes and periodic jokulhups or glacier-bursts. His works in the fields of geomorphology and soil erosion further emphasize the breadth of his interests.

Sigurdur maintained a remarkable productivity through the years, and published well over 200 papers and books. At the time of his

death Sigurdur was preparing manuscripts on the 1783 fissure eruption of the Laki crater-rim and its atmospheric effects on the northern hemisphere. Other works in progress included the volcanic history of Iceland and the long-awaited Iceland volume of the *Catalogue of Active Volcanoes of the World*. These compilations represent a life-time labor of love but were continually being updated to include new research and new eruptions. It is hoped these works will be published posthumously.

Sigurdur Thorarinnsson studied in the University of Copenhagen and the University of Stockholm, where he completed a classic doctoral dissertation in 1944 on the tephrochronology of Iceland. He returned to Iceland and became director of the Geology Department of the Museum of Natural History in 1947 and the first professor of Geology in the University of Iceland in 1968.

Another side of Sigurdur's personality, not generally known to his foreign colleagues, was his work as a poet and songwriter. He wrote hundreds of witty poems, which have become part of the Icelandic folksong tradition. His poetry, good humor, and inexhaustible energy in informing the general public about geological processes made him Iceland's favorite son. Sigurdur was never a controversial figure; his innovative research was always solid and has stood the test of time. He was fair and unselfish and generously shared his ideas with colleagues, who always held him in highest regard. His death is a great loss to the science of volcanology.

This tribute was written by Haraldur Sigurdsson of the Graduate School of Oceanography, University of Rhode Island, Kingston, RI 02881.

## Welcome to The VGP News

### Scope of the Section

Beginning with this issue of *Eos*, the Volcanology, Geochemistry, and Petrology Section of AGU will publish brief and timely scientific reports, highlights of conferences, statements of opinion, section news, and other topical information approximately every 3 months in a new section of *Eos* called "The VGP News."

Material for The VGP News will be handled by Eos Editor Bruce R. Doe, VGP Section President. J. V. Smith has appointed the following editorial group to work with Doe:

Peter W. Lipman, VGP Secretary, U.S. Geological Survey, MS 913, Federal Center, Denver, CO 80225 (telephone: 303-234-2901)

Charles A. Wood, SN4-NASA Johnson Space Center, Houston, TX 77058 (telephone: 713-483-3816)

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Joseph R. Smyth, 156 Piedra Lupa, Los Alamos, NM 87544 (telephone: 505-672-1925)

Peter W. Lipman  
Secretary, VGP

## VGP Opportunities

It is a great pleasure to introduce this first edition of The VGP News. I have enjoyed greatly the reports from the Oceanography section and was delighted to find that Brent Dalrymple and Peter Lipman were equally enthusiastic for starting a VGP equivalent. Chuck Wood has provided a very useful service with his Volcano News, and he plus Bill Leeman and Joe Smyth have the enthusiasm and general knowledge to put together valuable news items. But they will need the help of other members of the section in their work.

Our section faces major problems in capitalizing on the remarkable growth of knowledge and techniques. We need to integrate the laboratory and field aspects of our sciences. The new techniques, such as high-energy mass spectrometry and synchrotron-based experiments, will put further pressure on funding.

Our section could provide a useful public service by providing reliable information on geological hazards along with advice on the consequences of various social and political choices. We could also discuss the problems of the fractionation of the earth sciences into so many subgroups and possible ways of providing increased cooperation between them (e.g., the various geochemical-based societies).

On behalf of the whole section, I wish the editors and secretary all the best in this venture and thank them for their labors.

Joseph V. Smith  
President, VGP

## News & Announcements

### New Crater in Costa Rica

On April 9, 1983, we discovered a new explosion crater buried in the thick rain forest that covers the flanks of Arenal volcano in Costa Rica.

The previously undetected crater, which we named Crater I, is located between the twin volcanic system Arenal-Chato at 84°41'53"W and 10°27'42"N (Figure 1). It resulted from a phreatic explosion occurring probably during the 1968 explosive phase, in which three other well-known main craters (A, B, and C) were opened along a fracture on the western side of the Arenal volcano. Crater I has formed at the physical discontinuity that existed at the boundary of Arenal's

lavament that was created during the 1500 eruption cycle. The explosion, a small directed blast oriented 115° from the north, originated at a depth of approximately 50 m, leaving a circular crater 25 m wide and 1 m deep with an axis sloping 15° from the normal. The crater is made up of nonigneous lava blocks and lapilli and is now covered by ferns.

Crater I substantiates the existence of a deep, SE-NW-trending fracture system by which the twin volcanoes have evolved and gives important parameters in locating the zones of weakness in which future explosive activity may take place.

This news item was contributed by Andrea J. Iqbal, Centro de Investigaciones Geofísicas, Universidad de Costa Rica, Ciudad Universitaria Rodrigo Facio, Costa Rica, and Clark Poore, AGU Program, Department of Geology, Beloit College, Beloit, WI 53571.

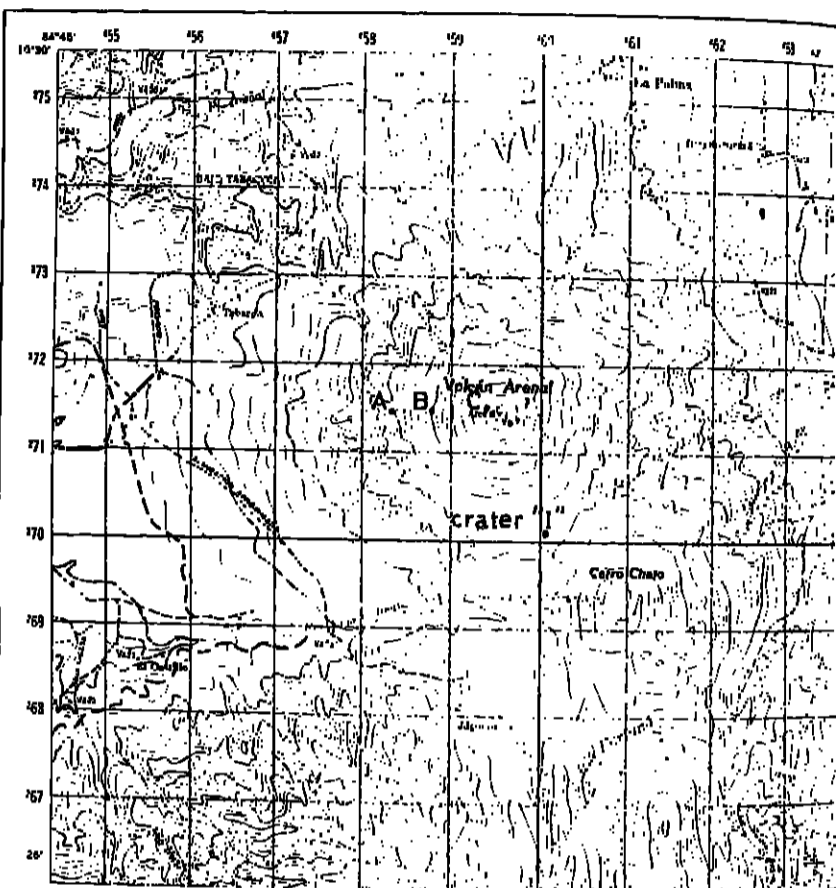


Fig. 1. Topographic map of Arenal-Chato twin volcanic system showing the location of Crater I. Craters A, B, and C, formed during 1968 explosive phase, are also shown. Map from the Instituto Geográfico Nacional, San José, Costa Rica. Scale 1:50,000.

## Irvine Receives VGP Award



T. N. Irvine

### Citation

Textbooks of not so long ago typically presented the study of stratiform igneous intrusions as a simple and straightforward exercise in nature's petrology laboratory. The fractional crystallization products of mafic magma were presumed to accumulate sequentially, largely in response to gravity. Those familiar with the literature of the past several years are aware, however, that the textbooks of the next generation will conclude that this model, if not actually wrong, is at best a gross oversimplification. Why this apparent fall from grace of such a seemingly useful concept?

One reason is that the number of geologists willing and able to visit the cold and lonely places where such bodies in the northern hemisphere invariably occur has grown. Consequently, the amount of geological information on the structure and composition of such bodies also has grown. But merely increasing the size of a cottage industry need not necessarily alter the nature of its product. So too the new directions in the study of layered intrusions are the result of far more than just a

growth in the amount of available data. It is primarily the result of a few creative people seizing new observations, combining them with theory and experiment, and offering new insights into the meaning of these observations.

The recipient of the 1982 VGP Award, T. N. Irvine, is a prominent example of such a person, and he is specifically honored for his studies of the Muskox intrusion in northern Canada. An appreciation of the work he has done there and the insights recovered from his studies may be gotten from his paper in the volume on *Physics of Magmatic Processes* (R. B. Hargraves, Ed., Princeton University Press, 1980). But any one of a number of his earlier papers on geological observations, theory, and laboratory experiments relating to the evolution of layered intrusions would be illuminating in this regard. It is difficult to avoid the suspicion that Irvine has a secret phone booth into which he steps to shed his mild-mannered exterior before writing papers of such intellectual force.

So what has Irvine done to clear our vision with regard to the meaning of layered intrusions? In general terms he has provided persuasive evidence that much more than crystallization and gravitational crystal settling occur in the Muskox and other intrusions. The importance of repeated injections of magma into a fractionating chamber, the mobilization of country rock, the mixing of fresh, fractionated, and contaminated magmas, the penetration of intercumulus liquids, the action of turbidity currents, and the operation of double-diffusive convection have all been recognized through Irvine's careful work. Although, as a consequence, layered intrusions can no longer be viewed as the result of the simple crystal fractionation and settling, they have actually become much more interesting petrological showcases for a rich variety of geophysical processes. For Neil Irvine's contributions to this important and fundamental transformation in petrological thinking, I am pleased to present him with the 1982 VGP Award.

Joseph V. Smith  
President

Volcanology, Geochemistry, and Petrology Section

### Acceptance

I am most pleased to be honored with this award and to know that my work on layered intrusions is appreciated to such an extent. This work has been going on now for more

than 25 years, so I presume that a considerable cumulative effect is reflected here. Over such a long time, one benefits through associations with many people, and I will take this occasion to mention those who have helped me most.

My list has a strong Canadian flavor, and it begins with Bruce Wilson at the University of Manitoba, where I was an undergraduate. When I think back, I realize that my career was practically determined by two or three of his lectures in which he described some of his own very perceptive work on layered intrusions and their ore deposits. Those lectures attracted my interest in the rocks that have since become my principal research subjects. Bruce also directed me to Caltech, which was the next step on my way.

Shortly after I arrived at Caltech, I learned that Jim Noble, who was then Professor of Economic Geology, had charge of a project in which he hired students to work on ultramafic rocks in southeastern Alaska. This appealed to the interest that Wilson had raised, so when the time came to find a job for the following summer, I sought Jim out. He signed me up to go to the Duke Island, where, as it turned out, we found the world's most beautifully layered ultramafic rocks. From that time on I was hooked! Most people who know southeastern Alaska shudder at all the rainy swampy places. But to me at the time, it was the most exciting place on earth. I literally thrilled at the mapping that unraveled complicated layering structures, multiple igneous and magmatic replacement bodies. During this work and through to its publication some years later, Jim Noble gave me patient support and encouragement, and I am greatly indebted to him.

# EOS

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Cover: A view of the 2.3-km-diameter Aleutian Volcano caldera of Akutan Island, south on January 16, 1983, is rare owing to the normally poor Aleutian weather conditions. Note the recent ash fall on the snow just to the left of the steaming, circular crater. A small ash eruption occurred from this cone in December 1982. In September 1978, a fairly large ash eruption occurred in which andesitic lavas flowed from the base of the steam-flooding cone over a large part of the caldera floor, through the northern breach in the caldera wall, and then down the northern slope of the volcano to within 1 km of the coast. During recent investigations, organic soils were found directly beneath parts of the large pyroclastic flow and air-fall deposits that resulted from the caldera-forming event. The carbon 14 age determined for this soil (three dates only) suggests that the Akutan caldera may have formed about 5,000 yr B.P. (Photo courtesy of John W. Reeder, State of Alaska Division of Geological and Geophysical Surveys, Anchorage, AK 99510.)

After graduation I worked for a summer with the Geological Survey of Canada on a helicopter survey in the Northwest Territories. On that survey we geologically mapped an area of approximately 60,000 square miles. This was a marvelous experience in itself, in part because the country was virtually unknown and in part because I made a transition from mapping at 50 feet to the inch at some places on Duke Island to mapping at 8 miles to the inch from a helicopter. There is nothing quite like that to broaden one's horizons! The more immediate significance of the survey, however, is that the area included a large, layered intrusion that had only just been discovered. That body is now called the Muskox intrusion. I saw Muskox only briefly that summer, but I was impressed that it was totally different from the Duke Island rocks, yet every bit as intriguing. I was delighted, therefore, several years later when the opportunity came for me to work on it full time.

When I joined the Muskox project at the Geological Survey in Ottawa, Charlie Smith was leader, and Chris Findlay, though still a student, was deeply involved. Charlie had produced a map of the intrusion that ranks with the best of its kind, and he and Chris were prime forces in promoting and carrying out a major drilling program to obtain continuous samples. Charlie, Chris, and many others who contributed, have long ago gone on to other endeavors. I am very much their beneficiary, and whatever success I have had with Muskox is largely owing to their excellent groundwork.

Since I moved to the Geophysical Laboratory, I have continued to work on Muskox, but my director, Hatten Yoder, has made it possible for me to also explore many other intrusions. I have been back to Duke Island; I have worked on Axelgild in British Columbia; Skerget in Greenland; Sillwaite in Montana; and Bushveld in South Africa. I have visited Rhum in Scotland and the Duluth Complex in Minnesota. The opportunity to compare all these bodies has been wonderful, all the more so because of Hat's enthusiastic support.

In the past few years, Skerget and Stillwater have been receiving most of my attention. At Skerget, I've gone back to detailed mapping to document layering structures and I have enjoyed the splendid scenery and exciting trips. My thanks here go to Alexander McBirney. Mac encouraged me to go to Greenland in the first place, and more than anyone he opened my eyes to the potential importance of double-diffusive convection as an igneous process. At Stillwater the feature of interest has been a platinum-palladium ore zone. This study, which has led deeply into double-diffusive convection and magma mixing, has been done in collaboration with three geologists with the Johns-Manville Corporation—Stan Todd, Doug Keith, and Don Schissel—and I am most grateful to them and their employers for the opportunity.

To round out my list, I would also mention Dick Jahns, who taught me useful mapping methods; Gerry Wasserburg and Sam Epstein, who impressed me with the value of applying physics and chemistry to geological problems; Hugh Taylor, with whom I have had countless discussions of layered intrusions; Hu Gabrielse, who gave me much help in work that I have done in British Columbia;

Gerhard von Gruenewaldt, who arranged a stimulating 3-month visit for me to the Bushveld Complex; and last but not least, my wife, Lorna, whose wisdom and spirit have been major factors in my career and who, together with our children, Michael and Kerri, gives my life its balance.

I have had many pleasures in working with layered intrusions, but I will admit also to the feeling that with all my opportunities I should have accomplished more. This award is very much a reminder in that respect as well, but if it helps to keep me going (as it should), then it will be all the more to my good. Thank you very much.

T. N. Irvine

## Meetings

### El Chichón Data

The March-April 1982 eruptions of El Chichón have produced the largest atmospheric impact of any eruption since at least Krakatau in 1883. The main geological variable that is responsible is the anomalously high S content of the erupted magma. The ultimate source of this sulfur is still unresolved.

Some highlights of the scientific papers dealing with the eruptions and presented at the AGU Fall Meeting in San Francisco, December 10-11, are discussed below. (The abstracts are in *Eos*, November 9, 1982, pp. 807-808, 809-812, and 1126-1127.)

Wendell Duffield et al. described the geologic setting. Although scanty information is available, El Chichón was an inconspicuous, dome-capped stratovolcano with active surface geothermal activity before the eruption. At least two prehistoric eruptions occurred in the last 1250 years. The volcano is built on volcanic and sedimentary rocks of Tertiary age which overlie Cretaceous sediments. A drill hole near the volcano into the Cretaceous section has penetrated evaporite beds. Duffield et al. suggested that these rocks may have influenced the magmatic volatile fraction of the 1982 magma.

Servando de la Cruz described ground observations of the eruption. The 1982 activity consisted of three main eruptions: March 28 at 2332 local time, April 3 at 1935, and April 4 at 0533. The first eruption destroyed part of the summit dome, produced an eruption column 17 km high, lasted about 5 h, and caused a widespread ash fall over southern Mexico, Belize, and northern Guatemala.

The second phase of the eruption was documented in a spectacular sequence of night-time photographs which show the growth of the incandescent eruption column and volcanic lightning. A pyroclastic surge occurred in the first 10 minutes of this eruption. Cruz's pictures show the collapse of the eruption column and the movement of a pyroclastic flow down one of the river valleys in San Francisco Leon. The flow front, brightly incandescent and apparently turbulent, was obvious in the photographs.

The third eruption produced an airfall deposit only from a similar magnitude eruption column. The three eruptions were similar in the volume of material erupted. Various speakers estimated the total volume erupted at 0.4-0.6 km<sup>3</sup> of dense rock.

As a result of the eruptions, there is now a

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## Dry Valley Drilling Project

L.D. McClintock, editor

Core analysis is the major emphasis of DVDP. The wealth of scientific data from these (first) rock drillings make a vital contribution to understanding the geologic and glacial history of the McMurdo sound area. The vast ice-free valleys of Antarctica virtually unexplored, became the research center for a cooperative international venture between the U.S., New Zealand, and Japan. DVDP chronicles the final reports of the U.S. scientists. The very significant conclusions in this volume will be the basis for the next generation of studies and projects to be carried out in Antarctica.

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crater occupying the site of the old dome, pyroclastic surge (or low aspect-ratio ignimbrite) deposits all around the crater, and pyroclastic flow deposits down river channels for several kilometers. These disrupted drainages and caused many secondary lahars.

A network of seismographs was operating in a six-station telemetered array for 2 years prior to the 1982 eruption. The data studied retrospectively due to the remoteness of the stations, and reported by S. K. Singh et al., show a seismic build-up which began weeks before the eruption, and increased sharply on March 1. The high seismicity based through March 28 but stopped completely 2 h before the first eruption. The depths of one type of earthquake, thought to be associated with the magma-groundwater contact, was about 3 km. There were also a significant number of quakes at 15-20 km depth. This suggested to de la Cruz that there may be a dual magma storage system.

J. Varekamp and J. Luthi in separate papers reported on the extent, petrology, chemistry, and mineralogy of the ash. The ash is fine-grained (85% < 1 mm), highly dispersed, and has the characteristics of a plinian trachyte to phreatophilitic ash deposit with three fall units, assumed to correlate with the three eruptions. The ash fell out of the atmosphere partly as aggregates, which Varekamp proposed were held together with sulfuric acid. The magma was an alkali-rich trachyandesite with 56% SiO<sub>2</sub>, 2.8% K<sub>2</sub>O and an extremely high S content (0.5-1.0% S). This S concentration is more than 10 times that "expected" for a magma with the composition of El Chichón's. It is also about 50-100 times greater than the 1980 Mount St. Helens dacite. Andesite, hornblende, augite, magnetite, sphene, and apatite are phenocryst minerals, but compelling evidence was given by Luthi to

(cont. on p. 452)

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(cont. from p. J51)

show that 1% volume anhydrite microphenocrysts observed in these rocks was also in equilibrium with the magma.

Initial isotopic data on S and O in the anhydrite obtained by R. Rye suggest that the evaporites below the volcano were not the source of the anhydrite. Lühr estimates the magma temperature was about 800°C before eruption and that it contained 4-5% H<sub>2</sub>O and 2.5% S.

J. Hoffer presented data showing chemical composition of the fallout varied with distance from the volcano in a manner consistent with atmospheric fractionation.

S. Self emphasized the point that explosivity of an eruption is a poor index of atmospheric impact, using examples from recent history. He suggested that modest-sized, explosive andesitic eruptions, similar to the El Chichón event except in the extreme S content, might be the most important cause of stratospheric optical depth perturbations. If andesitic eruptions can be shown to be typically S rich, this conclusion would be strengthened.

The atmospheric scientists presented basic data on the stratospheric effects of the eruption. There were many measurements documenting a 25-35% decrease in solar radiation at the earth's surface due to the El Chichón stratospheric particles. The Mauna Loa Observatory group reports that this is the largest decrease in atmospheric transmission in the 24-year record there.

A. E. Strong (NOAA-NES) showed that sea surface temperatures over a broad area of the equatorial Pacific were rising at an abnormal rate since the eruptions. The effects on North American weather may be to alter the storm tracks and result in an unusual, but not necessarily colder, winter in North America. A. J. Krueger (NASA-GSFC) showed that SO<sub>2</sub> from El Chichón in the stratosphere caused a spectral interference with the Nimbus 7 Total Ozone Mapping Spectrometer (TOMS). The interference wiped out the ozone experiment, but allowed the total mass of SO<sub>2</sub> released to the stratosphere to be estimated at 3.3 x 10<sup>12</sup> g. This is 10-15 times the mass estimated by different methods for Mount St. Helens.

This meeting report was contributed by W. I. Rose, Department of Geology, Michigan Technological University, Houghton, MI 49931.

## Opinion

### Forecasts and Predictions

In recent volcanologic literature, the terms forecast and prediction have generally been considered synonyms. *Wadge and Guest* (1981), however, in assessing the possibility that Mount Etna would erupt before May 1982, stated that "these are not predictions of specific events but general forecasts... based on the behavior of the volcano during the past seven years." *Lockwood et al.* (1976) used the term forecast in anticipating an eruption of Mauna Loa before the summer of 1978 on the basis of historical records. In contrast, *Wood and Whitford-Stark* (1982) used the terms forecast and prediction synonymously when they anticipated an eruption of Kilauea before the end of May 1982 by projecting records from 1975 to the end of 1981; in terms defined here, this statement was a forecast. The fact that all three of these forecasts proved incorrect indicates the relative uncertainty of simply projecting past records and it suggests the desirability of distinguishing, whenever possible, such general statements from more specific predictions based on repeated measurements of changing phenomena on a short time scale.

Three types of written public statements about volcanic activity at Mount St. Helens are issued by scientists at the Cascades Volcano Observatory of the U.S. Geological Survey and at the Geophysics Program of the University of Washington:

- A "factual statement" describes current conditions but does not anticipate future events; such statements are revised when warranted to keep the public and government informed of new developments.
- A "forecast" is a comparatively nonspecific statement about activity expected to occur weeks to decades in advance, issued commonly without data from repeated monitoring, and based on a projection of geologic, geophysical, or geochemical records. Another kind of forecast uses monitoring data whose implications are not well understood. Forecasts aid particularly in land use planning and in the development of emergency response plans.
- A "prediction" is a comparatively specific statement giving place, time, nature, and—ideally—size of an impending eruption. The likelihood of an eruption should also be stated, but such a statement is difficult to quantify.

Predictions are generally based on measurements of relatively short-term changes in longstanding patterns of activity. Predictions may evolve from forecasts and should become increasingly more specific as the eruption nears. At Mount St. Helens, a prediction

is issued a few hours to a few weeks before an eruption—any time there is a relatively clear view of future activity as judged from current similarities with past precursory patterns and from interpretations of the active volcanic processes. Predictions reduce risk to life and property and provide a public test of scientific hypotheses about volcanic processes. Stratigraphic studies led to a 1975 forecast of renewed activity at Mount St. Helens "perhaps before the end of this century" (*Crandell et al.*, 1975). On the basis of seismic, geodetic, and geologic data, forecasts for an eruption and landslides in the near future were issued in March and April 1980 before the catastrophic eruption on May 18, 1980. Forecasts in March and August 1981 anticipated dominantly nonexplosive behavior over the next months unless some reversal in geophysical or geochemical indicators occurred; these forecasts remain in effect.

Correct predictions were made of all 13 eruptions at Mount St. Helens from June 1980 to the end of 1982 on the basis of integrated geophysical, geodetic, and geologic monitoring. Predictions several days to 3 weeks before eruptions were based largely on patterns and rates of ground deformation of the crater floor and lava domes; predictions within about 3 days of eruptions depended chiefly on rates of cumulative seismic-energy release and increased numbers of shallow, volcanic earthquakes. Predictions in February and March 1983 were not as successful, owing in large part to poor weather, which curtailed most monitoring, and perhaps to subtle changes in behavior of the volcano.

Subdividing the broad category of anticipatory statements into relatively nonspecific forecasts and relatively specific predictions may have general applicability in volcanology. Volcanologists commonly are called upon to make statements about the future that are based either on projections of past geologic or geophysical records or on insufficient or poorly understood data. Such statements can probably be distinguished from those based on adequate, up-to-date data on changing conditions at a volcano; such a distinction is scientifically honest and can help public authorities in their evaluation of the statement. There will always be gray areas; in such instances, forecasts rather than predictions should probably be made. In many cases, however, the distinctions are relatively well defined, and the procedure used at Mount St. Helens can be considered.

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David A. Johnston, *Cascades Volcano Observatory, U.S. Geological Survey, Vancouver, WA 98661*

### Kilauea Revisited

"Predictions" of imminent volcanic eruptions are more successful than are "forecasts" of impending activity if we use the terminology defined by Swanson in the accompanying article. The implication is that, despite occasional intervals of periodically recurring eruptions, the long term (months to years) activity of volcanoes is stochastic. Once magma rises near the surface, however, and initiates measurable phenomena (harmonic tremor, inflation, increased fuming, etc.), a volcano appears to be locked into a nonreversible process leading to an eruption weeks to hours hence. Each type of forecasting is valuable, and USGS volcanologists have demonstrated that the basic monitoring and prediction techniques developed for effusive eruptions in Hawaii are transferable to explosive activity in the Cascades. But longer term forecasts, as pointed out by Swanson, are still largely unreliable.

Nonetheless, we believe that forecasts should continue to be made and published for two reasons. First, the forecasts may be correct, providing a longer time for planning of monitoring activities, evacuation plans, etc. Responsible forecasts also serve to increase awareness of volcanic hazards among local authorities, so that when eruptions do come, there has been at least psychological warning. Second, a forecast is based upon observed patterns of activity of a volcano and thus is also an attempt to describe and understand eruption processes. Faulty forecasts have one advantage over erroneous predictions: The former do not have the immediate social and political consequences of the latter (see *Bailey, 1978*, and numerous replies).

Our forecast of an eruption at Kilauea caldera before the end of May 1982 was wrong. November 1981 and continued monitoring by Icelandic scientists reveals no evidence for an impending eruption. We could attempt to neutralize our forecast failure by any or all of the following arguments:

- (1) Kilauea failed to maintain its previous 6-year pattern of activity.
  - (2) Inflation shifted to new areas immediately prior to our analysis, perhaps affecting magma supply processes and rates.
  - (3) Volcanoes do not erupt forever; it had to stop some time.
- All of the above are true; we did not make a mistake in our analysis or forecast—we simply had the bad luck to discover an eruptive pattern one eruption too late. Because the eruptive pattern has failed there are now no hints for forecasting possible future activity at Kilauea, but monitoring will provide data for future predictions.

## Books

### Cooke-Ravian Volume of Volcanological Papers

*Geological Survey of Papua New Guinea Memoir 10*, R. W. Johnson (Ed.), Geological Survey of Papua New Guinea, Port Moresby, 265 pp.

Reviewed by Chris Newhall

A splendid volume entitled *Volcanism in Australasia* and edited by R. W. Johnson (Elsevier, New York, 1976) introduced many readers to volcanoes of Papua New Guinea. Now, Johnson and the Geological Survey of Papua New Guinea have published an equally splendid sequel that is a tribute to volcanologists Rob Cooke and Elias Ravian, killed during the 1979 eruption of Karkar Volcano. From Bam and Blup Blup to Bagina and beyond, 25 papers in the new work cover a wide variety of topics—including reconnaissance mapping and stratigraphic studies, interpretations of legends and old historical records, detailed studies of Karkar lavas and Rabaul pyroclastic deposits, and documentation of the precursors and characteristics of some recent eruptions. A wide variety of volcanoes is also covered, from small stratovolcanoes and domes to large calderas.

Researchers of Papua New Guinea volcanism have used an innovative and pragmatic combination of historical records, geomorphologic and geologic information, and in recent years petrological and geophysical data to learn a great deal about their subjects. This book captures the full scope of these studies and in so doing tells us not only about specific volcanoes but also how to study them in spite of limited resources, difficult logistics, discontinuous exposures from island to island, dense tropical vegetation, and deep soils.

In several respects the *Cooke-Ravian Volume* complements *Volcanism in Australasia* and should be read with the latter in hand. Many papers in the later book assume familiarity with topics covered in the earlier one, e.g., tectonic and petrologic studies in Papua New Guinea. Together, these two volumes are a major step toward an updated version of the *Catalogue of Active Volcanoes for Australasia* (IAVCEI, Naples, 1957) and a comparison with the *Catalogue* shows that much has been learned over the intervening years.

A strong descriptive thread runs through the volume. This thread is both its fundamental strength and an appropriate reflection of the groundwork that needs to be done before one can get on to more interpretive studies. Descriptions of eruption precursors and characteristics are excellent. I must admit to wishing that some descriptions of older pyroclastic sequences or morphologic forms had been carried through to more interpretive overviews, but these gaps between description and interpretation can be a challenge to future workers. Several papers do go beyond description and are important contributions to an understanding of volcanic processes. A paper by McKee et al. on hydroeruptions at Karkar is an especially thorough and interesting examination of the mechanism of hydro- or phreatic eruptions, the very hazard that claimed the lives of Rob Cooke and Elias Ravian.

The volume is printed on high-quality paper stock and is clothbound. Its photographs are at once a strength and a weakness; their number and selection are excellent, but the quality of their reproduction is mixed, with many photographs blurred by poor printing. Perhaps in a second printing this fault could be corrected. Overall, the book is an excellent value at approximately \$30 (22 Kina).

The volume contains a glossary and abstracts in Tok Pisin (Papua New Guinea Pidgin) in an attempt to attract a wider Melanesian audience. At the very least this is symbolically important, and I hope that this wider audience is reached. Volcanologic studies are of interest not only to the international and the growing Papua New Guinean scientific communities, but are also of vital importance to the many people who live on or near Papua New Guinea's active volcanoes.

Chris Newhall is with the David A. Johnston Cascades Volcano Observatory, U.S. Geological Survey, Vancouver, WA 98661.

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### Managing the Ocean Resources of the United States: The Role of the Federal Marine Sanctuaries Program

D. P. Finn, *Lecture Notes in Coastal and Estuarine Stud.*, vol. 2, Springer-Verlag, New York, ix + 192 pp., 1982, \$16.

Reviewed by Giulio Pontecorvo

In 1969, the Stratton Commission report provided a plan for the systematic development of a national policy on marine affairs. In subsequent years no such systematic approach to a coherent marine policy was undertaken. The de facto policy approach of the 1970s was a plethora of individual legislative acts which provided specific de jure rules, but which left administration the complex problems of working out the administration of areas of overlapping authority, with conflicting or inconsistent goals and jurisdictions. The major acts of the 1970s, the Fish Conservation and Management Act of 1968, Mammals and Non-Migratory Birds—The Marine Mammal Protection Act of 1972, Coastal Zone Management Act of 1972, Endangered Species Act of 1973, Marine Protection, Research, and Sanctuaries Act of 1972; and others, are clear indications of national commitment to regulation of the markets for the output from the ocean sector. But while the need for intervention in markets was clear to legislators, the failure to play a systematic approach and provide guidelines adequate to permit the rationalization of complex problems dominated the political approach to ocean policy to ever-increasing administrative problems and ultimately to ineffective government programs.

In his monograph, *Managing the Ocean Resources in the United States*, Daniel P. Finn carefully documents certain of these legal and administrative issues that have arisen and around one of these pieces of legislation of the 1970s, the Marine Sanctuaries Program. The monograph starts by developing three case studies: (1) the oil and gas lease on Georges Bank which focuses on conflict of statutory issues, (2) the Santa Barbara Channel problem of overlapping regulatory authority, and (3) the resources of the outer continental shelf where there are gaps in the statutory authority.

In turn, these case studies provide the basis for examination of a set of specific questions: "Can federal agencies, administering diverse regulatory and protective programs, formulate coherent policies and consistent decisions on marine resource development? Should specific provisions be made for special marine resources or a high probability of serious user or resource conflict? To legislative and executive bodies? Should there be a marine resource conflict? To legislative and executive bodies? Should there be a marine resource conflict? To legislative and executive bodies?" (p. 9).

The case studies provide a complete review of the legal processes surrounding program implementation. With the case studies as evidence, the monograph then goes on to examine, in three more chapters, the specific issues, coordination between agencies, the problem of definition of programs, management difficulties, the institutional perspective of the managers, political pressures, etc.

This monograph is a valuable handbook, an important reference work, and also, in a sense, it is an object lesson in how not to do it.

There is one serious omission in the book. In general, to focus on legal and political issues is to leave out the underlying scientific basis for action. The concept of a sanctuary requires an adequate scientific basis to justify the economic and social analysis to justify the need to defend it against alternative uses and to give it a set of objectives that can guide management actions.

Finn has provided an important service by describing how the system worked. We need better understanding of its rationalization.

Giulio Pontecorvo is with the Graduate School of Business, Columbia University, New York, NY 10027.

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GEORGIA INSTITUTE OF TECHNOLOGY IS AN EQUAL OPPORTUNITY/AFFIRMATIVE ACTION EMPLOYER.

Geophysical/University of Saskatchewan. Subsequent to final budgetary approval, the Department of Geology and Geophysics will have a new tenured position in geophysics available July 1, 1984. Applicants should hold, or be about to receive, the Ph.D. or equivalent degree. They will be expected to teach undergraduate and graduate courses in geophysics and to build and maintain a vigorous research program. Excellent research opportunities exist in crustal and exploration seismology and in all fields of mining geophysics. The new recruit must occupy a Ph.D. position in geophysics, already have well-equipped geophysical and data-processing facilities. Applicants should send a letter outlining their teaching and research goals, accompanied by a full curriculum vitae including the names of at least three references, to Dr. W. G. Caldwell, Head, Department of Geology, University of Saskatchewan, Saskatoon, Canada S7N 0W0.

Research Scientist/Space Plasma Physics, University of Iowa. A research position is available in the Department of Physics and Astronomy, The University of Iowa, for theoretical and interpretative studies of waves in space plasmas. Specific emphasis is on the investigation of wave-particle interactions in planetary magnetospheres and in the solar wind. These investigations are to support the International Geophysics Year (IGY) program. The applicant must have a Ph.D. with good qualifications in plasma physics theory and should have some experience in the analysis of space plasma physics data. A full resume and the names of three references should be sent to the Department of Physics and Astronomy, The University of Iowa, Iowa City, Iowa 52242, telephone 319-335-5427.

The University of Iowa is an affirmative action/equal opportunity employer.

Research Scientist in Ice Core Analysis/Ohio State University. Applications are invited for a position in the Institute of Polar Studies, The Ohio State University, beginning October 1, 1983. Primary duties of the position will include operations and maintenance of the Coulter counters in the ice core laboratory and processing ice and firm samples. Minimum qualifications are BS degree in physical science or engineering with suitable laboratory experience (or equivalent experience). Please send application of no more than 1 page, to Dr. D. Randolph Wauke, Marine Research Associate II position, UNIVERSITY OF OHIO, 1930 N. High Street, Columbus, OH 43210.

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Postdoctoral Position in Hydrologic Modeling/University of Arizona. A postdoctoral appointment in the area of modeling and calibration of hydrologic rainfall-runoff models is available beginning September, 1983 in the Department of Hydrology and Water Resources, University of Arizona, Tucson, AZ. The initial appointment will be for one year. The salary will be \$20,000-\$25,000 per year, depending on experience. The primary source of funds is a grant by NSF for the improvement of the reliability of compartmental models. QUALIFICATIONS: The successful applicant must have received the Ph.D. degree in Hydrology and/or Systems Engineering or a closely related field by the starting date. Preference will be given to applicants with experience in the field of mathematical modeling identification and parameter estimation theory.

TO APPLY: Send a complete resume and the names of three references to Professor Sorosh Sorooshian, Associate Professor, Department of Hydrology and Water Resources, University of Arizona, Tucson, AZ 85721. Telephone: (602) 621-5151. The University of Arizona is an equal opportunity/affirmative action employer.

Research Scientist for International Ground Water Modeling Center. A position is immediately available in the International Ground Water Modeling Center (IGWMC), an international information center for ground water modeling. It organizes an annual series of short courses, provides assistance in workshops and seminars, and conducts a clearinghouse for ground water models, conducts a program in applied research on ground water modeling, and publishes the Ground Water Modeling Newsletter.

The successful applicant will have a Ph.D. in Civil Engineering/Hydrology with a background in quantitative ground water hydrology, including chemistry of ground water. The person must have at least one year of experience in modeling flow and transport processes and should be acquainted with computer research. A solid background in numerical and stochastic analysis is required. Incumbent will perform the applied research program of the Center, including exploring modeling needs and research trends, and technical evaluation of models, and will be involved in the continuous updating of the Center's model information system and in conducting the training programs, and in handling information requests.

The annualized salary for the position is \$28,000 for a 37.5 week work, typically from 8:30 a.m. to 5:00 p.m.

Interested applicants must include (1) number 042860 and social security number in a response by July 28, 1983 to:

Indianapolis, Indiana 46204  
ATTN: W.F. Shepherd  
An Equal Opportunity Employer

Postdoctoral Position/Naval Postgraduate School. The Ocean Turbulence Laboratory has available a postdoctoral position for a person interested in the analysis and interpretation of oceanic turbulence data. The tenure is for one to two years. The successful candidate should have a Ph.D. in physical oceanography and although experience with turbulence data is preferable it is not essential. The opportunity for involvement in data gathering expeditions is also available.

Resumes can be sent to Dr. R.G. Lueck, Code 661, Naval Postgraduate School, Monterey, CA 93943.

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University of Colorado, Boulder, Geochronol Position. Geochronol with active research programs in stable isotopes, radiative isotopes, and trace elements is being sought for a joint appointment in the Department of Geological Sciences and the Cooperative Institute for Research in Environmental Sciences (CIRES) of the University of Colorado.

The one-half time position within the Department of Geological Sciences is tenure track at the assistant or associate professor level with a starting salary of \$12,000-\$15,000 for the academic year. Teaching load will be half that of full-time faculty. The position within CIRES will be as a Fellow with appropriate office and laboratory space. One-half academic year salary will be guaranteed by CIRES for two years at the departmental rate, after which incumbent must generate higher CIRES salary from external sources. Incumbent may augment salary further by generating three months of summer salary from contracts and grants, and consulting. Applicants with experience, publications, and/or movable existing research equipment preferred. Preferred starting date would be January 1, 1984. Closing date for applications is October 1, 1983. Applications should include statement of research and teaching interests, experience, a full vitae, and four letters of reference.

Apply to Professor Charles Stern, Chairman, Geochronol Research Committee, Department of Geological Sciences, Campus Box 250, University of Colorado, Boulder, CO 80309.

The University of Colorado is an equal opportunity/affirmative action, Section 504 employer.

Université du Québec, Rimouski/Faculty Position in Geological Oceanography. The Université du Québec à Rimouski seeks qualified persons to fill the following position: Full-time professor of geological oceanography.

FUNCTIONS: The successful candidate will be required to teach courses at the undergraduate and graduate levels and to develop new courses in subjects such as mineralogy, stratigraphy and mineralogy, and will be expected to collaborate with existing research programs in the fields of tectonic boundary layer, biogeochemistry and coastal sedimentation.

REQUIREMENTS: The successful candidate must possess the doctorate in geological oceanography or marine geology with specialization in mineralogy and/or sedimentology, and direction research involving Quaternary marine deposits. Courses are given in French.

All applications will be treated confidentially, it is requested that candidates indicate on their resumes if they are immigrants given preference. Interested persons should send their curriculum vitae before August 15, 1983 to:

Directeur  
Département d'océanographie  
Université du Québec à Rimouski  
300, avenue des Ursulines  
Rimouski, Qc G5L 3A1.

Research Scientist II. The Solar-Terrestrial Theory Group at the University of New Hampshire seeks applications for a research scientist (e.g., theoretical plasma physics or related field) to collaborate with plasma fusion research, in the MHD processes in the solar atmosphere and the solar wind, and related energetic particle phenomena.

Minimum qualifications: Applicant must possess a Ph.D. or equivalent professional degree, with research leading to doctorate, with training in theoretical space plasma physics or a related field (e.g., theoretical plasma fusion research), in master's degree and at least three years of research experience which is closely related to project work. Salary range \$20,110 to \$31,200; normally starting salary set to exceed \$24,000. Resumes and three letters of reference should be sent before August 15, 1983, to: Dr. J. V. Hollweg, Department of Physics, University of New Hampshire, Durham, NH 03824.

The University of New Hampshire is an affirmative action/equal opportunity employer.

Iowa State University of Science and Technology, Department of Earth Science Research. The Department of Earth Science Research, University of Science and Technology, is seeking applications for a Research Associate position as an electron microscope specialist. The appointment will be a fully funded, permanent, twelve-month position. Salary will be commensurate with qualifications.

Primary duties are the operation and maintenance of a fully automated microscope with WDS EDS capabilities and the supervision of associated laboratory facilities. Additional duties include the instruction of research personnel in instrument operation. Ample opportunities exist for continuing education and career advancement in research involving the microanalysis of geological materials.

Applicants should have a M.S. degree in a science or engineering field, or equivalent experience, and must have had electron beam instrumentation. Persons with a working knowledge of WDS and EDS spectrometers and the accompanying computer operations and experience analyzing geological samples will be preferred applicants.

Application deadline is July 31, 1983. Later applications will be accepted if the position is not filled. Applications should include a complete resume, a statement of research interests and intentions, copies of publications and names of at least three references. Applications should be sent to:

Bert E. Norville  
Department of Earth Sciences  
Iowa State University  
203 Science I  
Ames, Iowa 50011

Iowa State University is an equal opportunity/affirmative action employer.

University of Arizona/Faculty Position. The Department of Hydrology and Water Resources invites applications for a faculty position in hydrology with a specialty in ground-water hydrology. Candidates must have a Ph.D. with suitable professional experience and must have demonstrated ability in the quantitative aspects of the topic. Appointment will be at the level of an assistant or associate professor. Interested individuals should obtain further information from:

Professor Stanley N. Davis  
Chairman, Search Committee  
Department of Hydrology and Water Resources  
University of Arizona  
Tucson, Arizona 85721  
602-621-3131.

The University of Arizona is an affirmative action/equal opportunity employer.

CNOOC Chair in Mapping, Charting and Geodesy (Hydrography)/Department of Oceanography, Naval Postgraduate School, Monterey, California. Under the sponsorship of the Commander, Naval Oceanography Command (CNOOC), a Chair in Mapping, Charting, and Geodesy (Hydrography) has been established in the Department of Oceanography, Naval Postgraduate School (NPS). The objective of the Chair is to promote research and research in hydrography, and to encourage collaboration with the Navy and the CNOOC.

Interested individuals should send their resumes and three letters of reference to be sent to Geophysics Fellowship Committee, Department of Terrestrial Magnetism, Carnegie Institution of Washington, 524 Broad Branch Road, NW, Washington, D.C. 20018.

Graduate Assistantships/Howard University. Howard University in Washington, D.C., offers a new graduate program for the M.S. degree in geoscience made possible by a grant from the Gulf Oil Company. Areas of specialization are field geology, geophysics, geochemistry, and meteorology/hydrology with remote sensing. Some stipends and assistantships are available. Potential students should write to Dr. Eric Christensen, Department of Geology and Geophysics, Howard University, Washington, D.C. 20059.

## SENIOR HYDROLOGISTS

### ARE YOU LOOKING FOR CHALLENGING ASSIGNMENTS? WE HAVE THEM IN:

- Problem Diagnosis
- Investigation Planning, Supervision
- Data Evaluation and Interpretation
- Action Planning and Investigations
- Expert Advice and Testimony

